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Geothermal Technologies Program

**Imaging Multi-Dimensional Electrical Resistivity Structure as A Tool in Developing Enhanced Geothermal Systems**

**PROJECT SUMMARY**

Project aims to ultimately increase economically viable geothermal resources in the U.S. and reduce the levelized price of geothermally-derived electricity by advancing the ability to image and interpret underground geophysical properties related to fluid flow in enhanced (engineered) geothermal systems (EGS). Since an increased fluid content due to fracturing, and the development of more conductive alteration minerals (clays, etc.) as a result of fluid flow, can give rise to an electrical resistivity contrast, electromagnetic (EM) methods of probing have been investigated and applied for many years. Development in this proposal of three-dimensional inversion capability for complementary EM/galvanic (DC) resistivity data sets which can run on serial PC's or low-cost clusters is intended to provide a tool for fracture zone mapping, and the evaluation of subsurface processes affecting fluid flow. It is also intended to provide technology pertinent to private industry, the contract surveying arm of which has taken the responsibility for EM/DC data collection whether for EGS purposes or more general exploration goals.

The 3-D inversion development herein addresses the principal facets of practical subsurface imaging technology: maximal solution stability, computational accuracy, high speed, minimal storage, and hardware affordability. It is our intention to bring meaningful 3-D inversion capability to the PC environment. Given advances in computer platforms, and the advances proposed here, the Gauss-Newton (G-N) parameter step known for its good convergence now appears practical for the largest data sets encountered so far in geothermal applications. Computational accuracy is ensured through use of a particular staggered grid implementation shown to have superior characteristics to others published so far. The chief bottleneck of the G-N approach has been laborious computation of the parameter sensitivities – in perhaps the most novel development of the project effort, this is overcome through application of the integral equations method. Storage, and run-time, are reduced further by porting the algorithm to an inexpensive but powerful Beowulf-type computer cluster. This is the type of parallel capacity hardware that is affordable by small companies.

Four data sets will be analysed using this inversion capability. The first will be the extensive collection of MT measurements (>100 stations) conducted at the Coso, CA, EGS site in 2003 and 2004. These results were taken mainly over the east flank region of high temperatures but limited permeability, which is the subject of a large hydrofracturing/stimulation experiment planned for spring of 2004. Data from an MT monitoring array running during this experiment will be inverted also against the initial reference model using an a-priori adherence approach developed by the P.I. The second data set is a group of about 65 evenly distributed MT soundings over the Karaha-Telaga Bodas andesitic system. The third set will be a multi-profile, CSAMT set from the Surprise Valley/Lake City geothermal prospect in northeastern California. This test will examine the ability of explicit accommodation of finite source effects to significantly extend the depth of exploration (hopefully by about a factor of three). Finally, a full multi-profile, simultaneous MT/DC array data set from the Battle Mountain area of northwestern Nevada will be inverted as a test of complete imaging capability using such a complementary electrical data set.